

Survey of Food Grain Preservation Methods used Against Insect Infestation among Vendors in Makurdi, Benue State, Nigeria

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ABSTRACT

Insect infestation of stored grains is a huge problem among food vendors in Nigeria. The present study was carried out to determine the methods of preserving grain food among vendors in selected markets of Makurdi metropolis, Benue State, Nigeria. Questionnaires were administered to 60 vendors in three selected markets. Results showed that Guinea corn, maize, and rice were the most consumed grains on daily basis. Groundnut and maize had the lowest storage time prior to insect attack, while guinea corn had the highest. Insect attack on stored grain was high (91.7%). About 93% of the vendors applied insecticide, while 7% used the sun-dry method. Three types of insecticide were reported: insecticide powder, insecticide tablet, and insecticide spray. The sun-dry method was described as stressful and difficult or time-wasting. Vendors preferred the insecticide method because it is highly effective, time-saving, and easy to apply. Two disadvantages of the chemical method include the possibility of causing harm to humans and the high cost. The safety of food grains sold to consumers is in doubt. This calls for appropriate regulatory measures among stakeholders.

KEYWORDS: food grain; health; insect attack; preservation; safety

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1. Introduction

Food is a basic necessity of life. Grains are obtained from plants in the form of seeds as products of sexual reproduction. These grains are used as foods for humans, livestock, and other animals. In Nigeria, food vendors are constrained by the challenges of storing quality grains to maintain good market values [1]. This is because consumers detest deteriorated grains. Insects are major causes of grain deterioration by causing irreversible damage to grains in storage [1].

Food vendors must ensure timely and effective preservation and protection of grains against insect attacks. This is because damaged seeds are not attractive to

consumers and, therefore, not marketable. The situation may be aggravated by fungal colonization, where the grains are further reduced to form powdery substances caused by the heat and moisture during insect colonization [2, 3]. To reduce loss of grain quality, insects must be controlled by the Nigerian vendors who store the grains before selling, depending on the time taken to sell the products. While some insects are transported from farms during harvesting and handling, natural infestation is inevitable [4, 5].

Many species of insects are found in food grains, but only around 100 species have been documented [6-8]. They have been classified as primary, secondary, or tertiary insects. While the primary insects pierce through healthy grains before laying their eggs as in weevils, the secondary and tertiary types feed on damaged seeds. Common examples include rice weevil (*Sitophilus oryzae*), rice moth (*Corcyra cephalonica*), grain borer (*Rhyzopertha dominica*), pulse beetle (*Callosobruchus maculatus*), and flour beetle (*Tribolium castaneum*) [6, 7]. These insects are well documented in Nigeria. The effects of grain biodeterioration caused by insect infestation cannot be over-emphasized. The major effects are economic and financial losses [6]. Others are nutritional loss, grain weight loss, viable value loss, health risk, increased cost, and emotional disturbance [8].

Storage methods are crucial in preventing losses caused by insect pests and other pathogens. The common methods include physical or traditional, chemical, and biocontrol [9]. In Nigeria, the traditional method is often practiced among farmers being the cheapest and simplest method though laborious. The traditional method has now been overtaken by the chemical method, especially among the vendors who sell the produce to consumers. Yet, they claim not to use chemicals in preserving food grains sold to consumers due to regulatory checks. However, there are rising cases of cancers that have been linked to the use of food protectants in Nigeria [9]. Various synthetic pesticides used to protect stored grains have hazardous effects on man and the environment. They persist and eventually enter the food chain and become amplified along with the trophic level as they cause significant damage [9, 10]. This practice has been banned in many countries. To overcome the hazards associated with the use of synthetic pesticides, indigenous practices are encouraged. Biological products such as plant materials are more advantageous than the chemical method being environmentally friendly, cheap, natural, safe, and non-toxic to humans [11-13]. Therefore, these properties satisfy basic environmental laws enacted by various national and global environmental agencies [14].

Insect infestation of stored grains is a huge problem among vendors across all markets in Makurdi, Benue State, Nigeria. The situation has frustrated some vendors out of business due to economic and financial losses. At the same time, consumers of grains such as pulses, cereals, and oilseeds often complain that vendors use chemicals to preserve their grains. The effects of chemical preservatives are lethal to human health; hence, the safety of consumers may not be guaranteed, especially when health complications such as cancer cases are common [11-13]. Information on the actual methods used to preserve food grains sold to the public by the vendors is scarce in the study area.

There are many markets situated in the Makurdi metropolis of Benue State, Nigeria. Wurkum, Wadata, and Northbank are the three largest markets that deal majorly in food and food products in large quantities; hence food vendors are highly patronized in these markets. This forms the basis of selecting the markets as choice locations for study sampling. This study aimed to determine the methods of preserving grain food among vendors in the three selected markets of Makurdi metropolis, Benue State, Nigeria.

2. Methodology

2.1 Study Area

This study was carried out from 30th November 2021 to 18th February 2022 in Makurdi, the capital of Benue State in Nigeria. The city is located in North Central Nigeria, along the Benue River. The major ethnic groups are the Tiv, Idoma, and Igede. Makurdi town lies between Latitude 7° 44'N and Longitude 8° 32'E, covering an expansive area of 820 km². The vegetation type is the Guinea Savannah type that supports agricultural activities [15]. Benue State is popularly called the food basket of the nation because of its intensive food production and farming activities. There are many markets in rural and urban areas of the State where agricultural produce are sold. The major markets in Makurdi, the State capital, are the Wurukum, Wadata, and Northbank. Information about the markets are given in Table 1.

2.2 Design of Structured Questionnaire Sample

A structured questionnaire sample was designed and administered to food vendors [16]. The targeted respondents are food vendors that sell grains in the markets. Information was obtained from each respondent on the following: socio-demographic data (vendor's name, age, sex, phone number, and market used), average daily patronage, type of food grain/s sold, experience with insects in food grain, effects of insect infestation, the fate of damaged grains, information on grain storage, methods of grain preservation among vendors, consumers safety concern during grain preservation, knowledge of harmful effects of some methods of preservation, the popularity of insecticides among vendors and traditional methods of food preservation known to vendors.

2.3 Sampling

Three major markets where food is sold were specifically chosen within Makurdi for the study. They were Wurkum, Wadata, and Northbank. These are the three largest markets that deal majorly in food and food products in large quantities with a high number of daily patronage. Questionnaires were administered to 60 vendors in three selected 20 vendors per market. The criteria for selecting vendors were: quantity of food sold (only major dealers were selected), variety of food grain sold (those selling more than two types of food grains were selected), and vendors' consent (those who

Table 1. Information on the selected markets.

Market	Type	Description of location	Number of food vendors sampled
Wurukum	Urban	A large market located in the heart of the Makurdi metropolis.	20
Wadata	Urban	A large market located in Makurdi metropolis far apart from Wurukum market, which is dominated by the Hausa community.	20
Northbank	Urban	A large market located in the extreme and Northern part of Makurdi metropolis.	20
Total number of vendors			60

agreed to be interviewed were selected). The sampling size was limited due to the difficulty in getting vendors that met the three criteria. The technique employed was a survey method with open-ended questions.

2.4 Interview and Documentation

Interview was conducted in the English local dialects of the study location, such as Tiv, Idoma, Igede, and Hausa. Responses were documented in the space provided in the questionnaires by the literate respondents. The illiterates were assisted in filling the questionnaires according to their responses. Pictures were taken where necessary.

2.4 Packaging of Questionnaires

Filled questionnaires were well packaged and arranged in three envelopes according to the market sampled for analysis.

2.5 Data Analysis

All information obtained from each respondent were entered into Microsoft Excel. Descriptive method applied were the frequency distribution, tally system, percentages, bar chart, and pie distribution.

3. Results

The sex status of respondents (Table 2) gave 73.3% female vendors and 26.7% male vendors in the three markets. Vendors were of the following age distribution (Table 3): <30 years (43.3%), 31-40 years (43.3%), 41-50 (11.7%) and 51-60 (1.7%). About 86.6% of the food vendors were ≤40 years of age. Respondents specialized in selling eight food grains across the three markets. They were: beans, maize, garri flour, groundnut, guinea corn, millet, rice, and soya beans (Table 4). The highest sampling based on food type was observed in millet (seven vendors in Wurukum market), rice (six vendors in Wadata market), and maize/guinea corn/rice grains (four vendors each in Northbank market). Out of 60 samples across the three markets, rice grain had the largest sample of 13 vendors, followed by guinea corn (11 vendors) and millet (10 vendors), as shown in Figure 1. Guinea corn had the largest daily patronage in

Table 2. Sex status of respondents.

Sex of vendors	Wurukum	Wadata	Northbank	Total
Male	5 (25%)	2 (10%)	9 (45%)	16 (26.7%)
Female	15 (75%)	18 (90%)	11 (55%)	44 (73.3%)
Total	20	20	20	60

Table 3. Age of respondents.

Age of vendors (years)	Wurukum	Wadata	Northbank	Total
<30	4 (20%)	10 (50%)	12 (60%)	26 (43.3%)
31-40	12 (60%)	7 (35%)	7 (35%)	26 (43.3%)
41-50	4 (20%)	2 (10%)	1 (5%)	7 (11.7%)
51-60	0	1 (5%)	0	1 (1.7%)
Total	20	20	20	60

Table 4. Major grain sold and maximum daily patronage per vendor.

Type of grain	Wurukum		Wadata		Northbank		Total maximum daily patronage
	Number of vendors sampled	Maximum daily patronage	Number of vendors sampled	Maximum daily patronage	Number of vendors sampled	Maximum daily patronage	
Beans	2	48	3	70	2	48	166
maize	1	70	2	68	4	85	223
Garri	1	53	3	78	0	0	131
Groundnut	0	0	1	70	1	80	150
Guinea corn	4	89	3	87	4	78	254
Millet	7	69	1	56	2	65	190
Rice	3	67	6	79	4	70	216
Soyabeans	2	53	1	85	3	70	208
Total		449		593		496	1538

Wurukum (89 persons) and Wadata markets (87 persons), while maize had the largest daily patronage in Northbank market (80 persons). The combined results showed that Guinea corn (254 consumers), maize (223 consumers), and rice (216 consumers) were the top three patronized food grains in the three markets (Figure 2). Prior to the emergence of insects, the maximum storage time for the various food grains varied between 4-12 months for maize; 6-12 months for beans and soya beans; 8-12 months for rice; 9-12 months for millet; 10-12 months for garri and guinea corn; and 5-6 months for groundnut (Table 5). Groundnut and maize had the least average length of storage of 5.5 and 7 months, respectively, before insect attack (Figure 3), while guinea corn had the highest value (11.3 months), followed by millet (11 months).

All vendors reported the occurrence of insect attacks on their food grains in the Wurukum market (Table 6). A total of 17 out of 20 vendors in Wadata market also reported insect attacks, while 18 vendors reported insect manifestation in the Northbank market. In total, insect attacks had a prevalence of 91.7% in the three markets. Weevil infestation called “ivyungu” in Tiv language was commonly reported in all grains except in garri flour, where the presence of maggot was reported. No vendor denied insect attack, although 8.3% did not respond to the question. All vendors

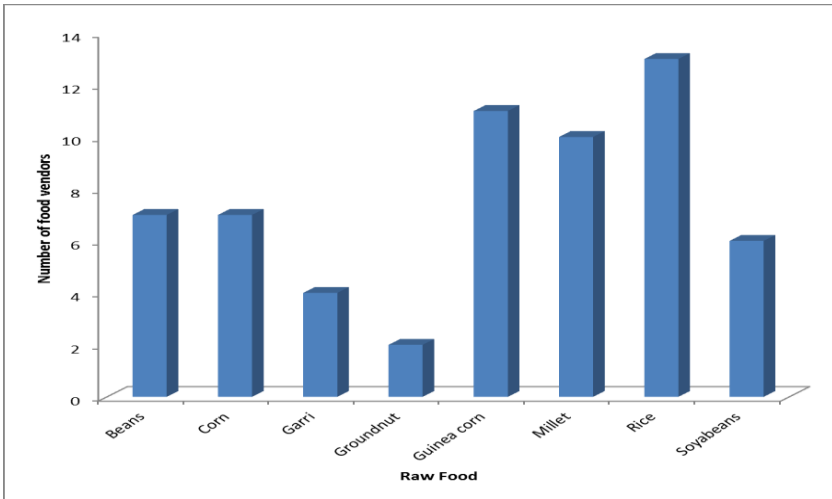


Figure 1. Total number of vendors sampled per food grain.

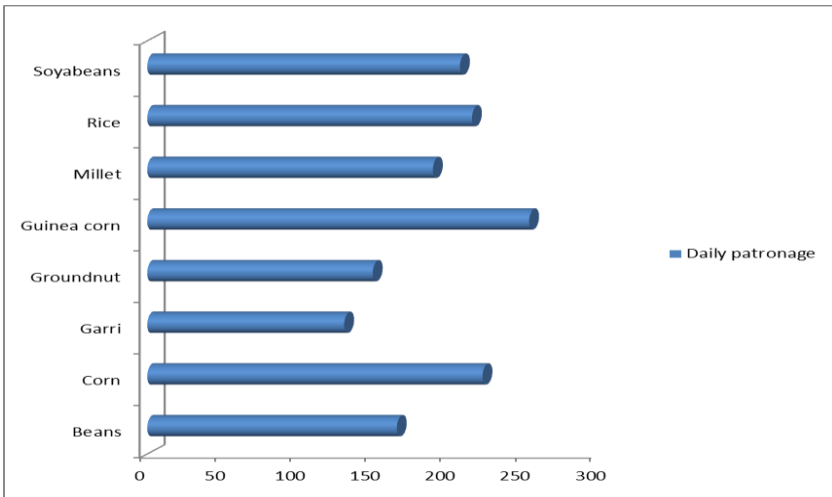


Figure 2. Maximum daily patronage per food grain sold.

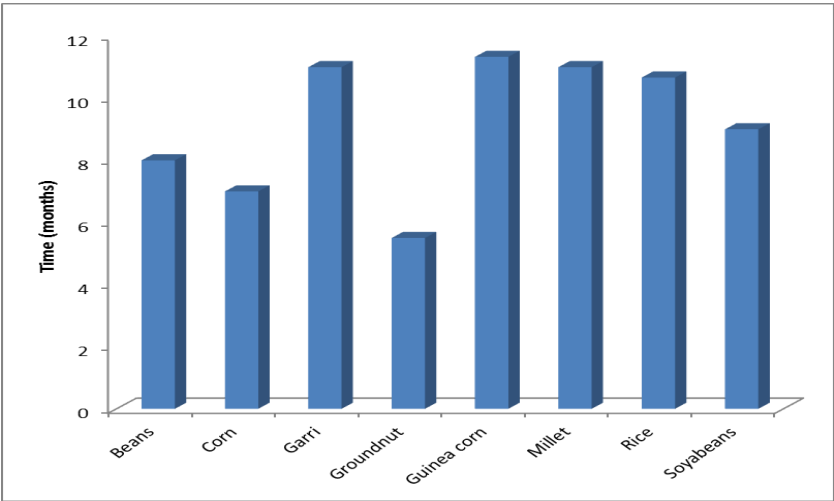


Figure 3. Average length of storage before insect manifestation.

Table 5. Maximum storage time (months) of food grains before insect manifestation.

Food type	Maximum storage time (months) before insect manifestation		
	Wurukum	Wadata	Northbank
Beans	6	6	12
Corn	5	4	12
Garri	10	12	0
Groundnut	0	6	5
Guinea corn	12	10	12
Millet	12	9	12
Rice	8	12	12
Soyabeans	9	12	6

Table 6. Presence of insects in food grain sold.

Responses	Wurukum	Wadata	Northbank	Total
Yes	20 (100%)	17 (85%)	18 (90%)	55 (91.7%)
No	0 (0%)	0 (0%)	0 (0%)	0 (0.0%)
No response	0 (0%)	3 (15%)	2 (10%)	5 (8.3%)
Total	20	20	20	60

All insect types = weevil (called ivyungu in Tiv) in all grains and maggot in garri

interviewed lamented the negative effect of insect attack on sales of their grains (Table 7). Vendors did feel bad when insect destroyed their grains, just as the consumers did feel disappointed and often unwilling to buy the insect-infested grains. About 93% of the vendors applied insecticide in their grains to control insects, while 7% used the sun drying method. Three types of insecticides were reported in the three markets: insecticide powder (68.3%), insecticide tablet (23.3%), and insecticide spray (1.7%). Only insecticide powder and tablets were used in the Wurukum market (90%), while the three types were used in the Wadata market (90%). In contrast, insecticide powder was solely applied in the Northbank market (100%), as given in Table 8. The safety level of the insecticide used among respondents varied from very high (55%) to high (34%), average (7%), or low (4%). As given in Table 9, about 56.37% of the vendors used insect-damaged grains to feed animals, while 25% of the vendors disposed them. About 16.7% sold them at a reduced price while 1.7% converted them into other valuable products such as in making local bean cake called “okpa”.

About 36.7% of respondents claimed that they utilized the sun-dry method of preservation because it is natural and harmless, followed by effective drying (28.3%) and cost effective (23.3%) (Table 10). A major disadvantage of the sun-dry method was given as a stressful and difficult method (58.3%), while 36.7% of respondents believed it wastes a lot of time (Table 11). Reasons for preferring the chemical method are given in Table 12. The chemical method is highly effective as it kills all insects, according to 41.7% of the respondents. It is time-saving (26.7%) and easy to apply (18.3%), while 13.3% claimed that there was no other better alternative. Two disadvantages of the chemical method as presented by the respondents were: being harmful to human health (56.7%) and high cost (21.7%), while 21.7% claimed that the chemical method had no disadvantages (Table 13).

4. Discussion

Young people and the middle age dominate the business of selling food grains in the market, mostly females. Insect infestation of food grain is a major problem confronting the vendors in the three markets sampled. Vendors do not have knowledge of the specific type of insect as they are known as weevils or beetles or “ivyungu” in Tiv language. Results are consistent with previous findings which found that infestation caused by insects imposed several losses to the vendors and consumers [8]. Insect attack remains the most devastating challenge in the food business. This is because insects and other pests are known to grow in a suitable energy source in a geometric fashion similar to the bacterial growth pattern. The larvae of insects are known to have destructive activities on stored seeds through feeding, which often biodeteriorates the seed and reduces its weight [17]. The problem becomes more compounded under chemical treatments, which may witness a phenomenon of pest resurgence [18].

The present findings also showed that guinea corn, maize, and rice are highly consumed in Makurdi as the grain types had the largest number of consumers, according to the vendors. Oil grain, cereals, and pulses have short-term storage before insect infestation and therefore require serious preservation and checks from time to time. A high percentage of vendors (93%) applied insecticide in their grains to control insects. This result is disturbing because insecticides have serious health and environmental implications [11, 12]. Chemicals are declared ecologically unsafe because they persist for a longer period in the environment and enter the food chain. It has been

Table 7. Effect of insect attack on sales grains sales.

Responses	Wurukum	Wadata	Northbank	Total
Negative	20	20	20	60
Positive	0	0	0	0
No effect	0	0	0	0
Total	20	20	20	60

Table 8. Type of insecticide used among vendors.

Responses	Wurukum	Wadata	Northbank	Total
Insecticide powder	9 (45%)	12(60%)	20 (100%)	41 (68.3%)
Insecticide tablet	9 (45%)	5 (25%)	0 (0%)	14 (23.3%)
Insecticide spray	0 (0%)	1 (5%)	0 (0%)	1 (1.7%)
Total	18 (90%)	18 (90%)	20 (100%)	56 (93.3%)

Table 9. Fate of insect damaged grains.

Responses	Wurukum	Wadata	Northbank	Total
Sell at reduced price	8 (40%)	2 (10%)	0 (0%)	10 (16.7%)
Feed animals	10 (50%)	6 (30%)	18 (90%)	34 (56.37%)
Dispose	2 (10%)	11 (55%)	2 (10%)	15 (25.0%)
Others (specify)	0 (0%)	1 (55)	0 (0%)	1 (1.7%)
Total	20	20	20	60

Others specified= for “okpa”

Table 10. Perceived reasons for sun-dry method.

Reasons	Wurukum	Wadata	Northbank	Total
Natural and harmless	10 (50%)	5 (15%)	7 (35%)	22 (36.7%)
It dries very well	3 (15%)	6 (30%)	8 (40%)	17 (28.3)
Cheap	3 (15%)	6 (30%)	5 (25%)	14 (23.3%)
No response	4 (20%)	3 (155)	0 (0%)	7 (11.7%)
Total	20	20	20	60

Table 11. Perceived reasons why vendors do not like sun drying.

Reasons	Wurukum	Wadata	Northbank	Total
Time wasting	5 (25%)	7 (35%)	10 (50%)	22 (36.7%)
Stressful/difficult	12 (60%)	13 (65%)	10 (50%)	35 (58.3%)
Short term protection	1 (5%)	0 (0%)	0 (0%)	1 (1.7%)
Reduction in quantity	1 (5%)	0 (0%)	0 (0%)	1 (1.7%)
Causes dormancy	1 (550)	0 (0%)	0 (0%)	1 (1.7%)
Total	20	20	20	60

Table 12. Perceived reasons why vendors apply chemicals to preserve grains.

Reasons	Wurukum	Wadata	Northbank	Total
Easy to apply	3 (15%)	5 (25%)	3 (15%)	11 (18.3%)
Time saving	4 (20%)	6 (30%)	6 (30%)	16 (26.7%)
Effectiveness	8 (40%)	7 (35%)	10 (50%)	25 (41.7%)
No other better choice	5 (25%)	2 (10%)	1 (5%)	8 (13.3%)
Total	20	20	20	60

Table 13. Disadvantages of chemical preservatives.

Reasons	Wurukum	Wadata	Northbank	Total
Harmful to health	12 (60%)	14 (70%)	8 (40%)	34 (56.7%)
Costly	6 (30%)	3 (15%)	4 (20%)	13 (21.7%)
None	2 (10%)	3 (15%)	8 (40%)	13 (21.7%)
Total	20	20	20	60

reported that certain insect pests have acquired resistance against most insecticides [11]. Due to the inimical and toxic effects of chemical preservatives [18], synthetic pesticides are formulated with heavy metal residues and constitute a significant source of environmental pollution [12, 19]. Many of these metals, such as Cd, Pb, and Cr, are carcinogens and are involved in several diseases, including Alzheimer's, Parkinson's, multiple sclerosis, osteoporosis, developmental disorders, and failure of several organs (e.g., heart, kidney, lungs, immune system) [11]. Different studies have shown varying amounts of heavy metals in various food sources in Nigeria [19, 20]. The 1992 United Nations Earth Summit recommended a drastic reduction in the use of chemical biocides for the biosphere to remain sustainable [21]. It is therefore important to seek alternative means of controlling unwanted insects.

The use of insecticide powder is the most common in the study area. It is known that powders have the ability to infiltrate into all available spaces between stored grains and spread to all parts of the seeds. Powdered materials are mixed thoroughly with seeds and not localized like the pellet form, although emission of gaseous substance is common. Vendors do not have knowledge of the generic name, dosage, and specifications of the insecticide they apply. Indiscriminate and frequent use of insecticides is observed. Also, vendors have no knowledge of the approval status of the insecticide they use because many chemical insecticides have been outrightly banned from the public domain by food regulators due to their high toxicity [22]. Vendors are aware that it may cause health damage. Still, there is no other potent method, so they have no choice but to use insecticides because it is more effective, easy to apply, and time-saving, without minding the cost since vendors will factor this into the pricing of commodities. Many respondents claim that the type of insecticides they use is safe for human health without any research that can back up their claims. The only proof they could provide was to quote the manufacturers who are into the business of making insecticides for profitability. The pieces of information given above are a major worrisome trend.

The outcome of this study has shown that food vendors in the study area have no alternatives to applying chemicals to control insect as against consumers' protection laws in Nigeria as in other countries [11, 17, 23]. The only traditional method known to the vendor was the sun-dry method. It is not commonly used though vendors have full knowledge of it. The vendors did not want the sun-dry method because it consumes a lot of time and space. It was also difficult and stressful. It leads to a reduction in the quantity of the grains after each sun drying. It is prone to attack by animals such as goats and birds that are left loose to move around. Many safe traditional methods are available that could be used apart from sun-drying method. These include the use of ash, common salt, and plant-based sources such as pepper, garlic, turmeric, castor powder, lime powder [17], and leaves that are documented for their insecticidal properties, such as *Azadirachta indica* and *Plumeria* species plant [23, 24, 25, 26]. The powdered leaves are mixed with seeds and filled in the bags or storage bin. There is a need to popularize these traditional methods among vendors. Also, there is a need to sensitize the public on the danger of selling or consuming chemically-treated food grain and the need to adopt safer organic methods. This study also suggests the need to educate farmers and vendors on the appropriate measures to be taken in post-harvest handling of grains for long-lasting insect-free storage. Knowledge of insect type, morphology, behavior, and life cycle is also essential in controlling insect attacks on food grain. The present study was limited to information obtained from vendors with informed consent or approval for the interview and those selling a large quantity of food grains of more than two types. The generic names of the insects found in the food products and the type of chemical insecticide control were not documented. Further studies are required to ascertain the generic name of the insecticide and the dosage applied as the vendors lack the appropriate knowledge of specific requirements of chemical preservation method and whether the chemical used has been banned or not by regulators.

5. Conclusion

Guinea corn was the most patronized grain, followed by maize and rice among consumers. Insect attack was high across the three markets. All vendors interviewed lamented the negative effect of insect attacks on sales of their grains. About 93% of the vendors applied insecticide in their grains to control insects. Vendors preferred the insecticide method because it is highly effective, time-saving, and easy to apply. It is evident that grain food vendors in the study area used insecticides as the primary method of preservation at the expense of consumers' health. The safety of food grains consumed is in doubt, therefore, a public health concern. The outcome of this study calls for appropriate precautions and regulatory measures among stakeholders, including punitive measures and enforcement. Consumers are advised to take precautionary measures to study the food grains before buying. Food items with indicators of chemical insecticides such as color change, odor, and particulates should be rejected. All food items should be boiled and washed thoroughly before cooking.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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